

§47. Behavior of Magnetic Island Transition Hysteresis in Time-varying Resonant Magnetic Perturbation

Narushima, Y., Sakakibara, S., Watanabe, K.Y.,
Funaba, H., Nishimura, S., Ohdachi, S., Suzuki, Y.

Behaviors of magnetic islands in helical plasmas are an attractive topic by virtue of its effect on the MHD stability. In helical plasmas such as LHD and TJ-II, it has reported that the magnetic islands show spontaneous behavior of growth/healing during the discharge. In the LHD experiment, the saturated island states can be clearly divided in to two regions in the space of plasma beta β and collisionality ν ⁽¹⁾. In the magnetic configuration with the *static* resonant magnetic perturbation (RMP) making the vacuum island, the change of the poloidal flow causes the magnetic island transition ⁽²⁾. Through those studies, it has been clarified that the plasma parameter (β , ν , ω_{pol}) effects on the magnetic island under the *static* RMP. Subsequently, it is interested in the island behavior under the condition with *time-varying* RMP with fixed (constant) β and ν . If plasma parameters are fixed and RMP is changed, the pure response to RMP of plasma can be clarified. Figure 1 shows two cases of discharges with *time-varying* RMP. In the beginning of the case of increasing RMP (Fig.1 left), magnetic island is suppressed until $t = 7$ s. From the local flattening size of T_e profile, the island width (w) cannot be determined (Fig.1 left (f)). The amplitude of the plasma response field $\Delta\Phi_{m=1}^{pl}$ (unit of [Wb] detected by non-planar flux loops) indicates same value of that of external field (RMP) $\Delta\Phi_{m=1}^{ext}$ (converted to an equivalent value at the flux loop loops). When the RMP exceeds the certain value, the island suddenly appears at $t = 7$ s. Its width becomes larger than that of the vacuum island (w_{vac}) indicated by the dashed line. At the time of transition from suppression to growth, the phase shift $\Delta\theta_{m=1}$ shows rotation from anti-phase ($\Delta\theta_{m=1} = -\pi$ rad) to in-phase ($\Delta\theta_{m=1} = 0$) in the ion diamagnetic direction. On the other hand, for decreasing RMP (Fig.1 right), the w still remains its width larger than w_{vac} even if the RMP falls to almost zero. The difference between w and w_{vac} gradually goes up with time because the $\Delta\Phi_{m=1}^{pl}$ is almost constant whereas the $\Delta\Phi_{m=1}^{ext}$ decreases through the discharge. In both cases (RMP ramp up and down), plasma β and ν are almost constant. From these experimental results, the clear hysteresis can be seen as shown in Fig. 2. These experimental results mean that the sufficient reduction of the RMP is required to re-suppress the magnetic island enlarged by the increasing RMP, and are consistent to the theoretical prediction whose model is based on the balance of electromagnetic and viscous torques considering the curvature driven tearing mode ^(3, 4).

- 1) Y. Narushima, et al., (2008) Nucl. Fusion **48** 075010
- 2) Y. Narushima, et al., (2011) Nucl. Fusion **51** 083030
- 3) S. Nishimura, et al, "Nonlinear stability of magnetic islands in a rotating helical plasma" to be submitted
- 4) C. C. Hegna, (2011) Nucl. Fusion **51** (2011) 113017

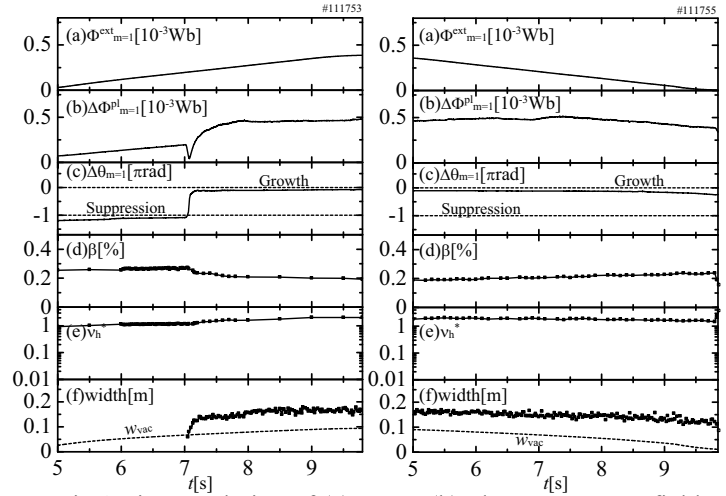


Fig.1 Time evolution of (a) RMP, (b) plasma response field, (c) phase shift, (d) beta, (e) collisionality and (f) island width. (Right: increasing RMP, Left : decreasing RMP)

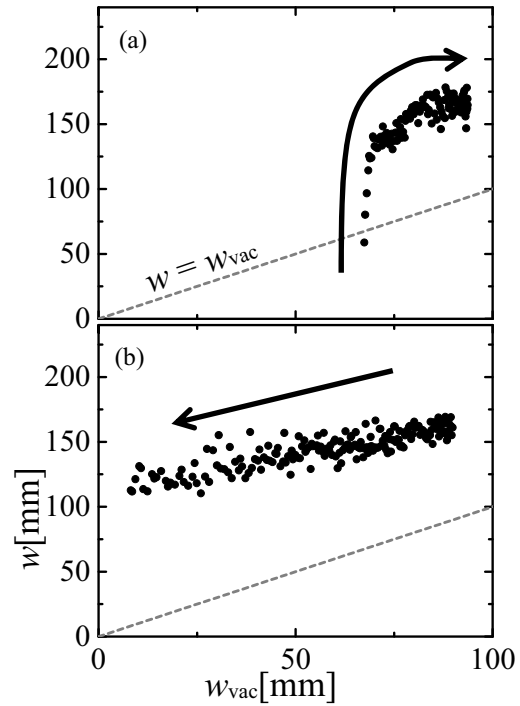


Fig.2 Time trajectories of island width when vacuum island changes (a) increasing RMP (b) decreasing RMP. Arrows mean time evolution.